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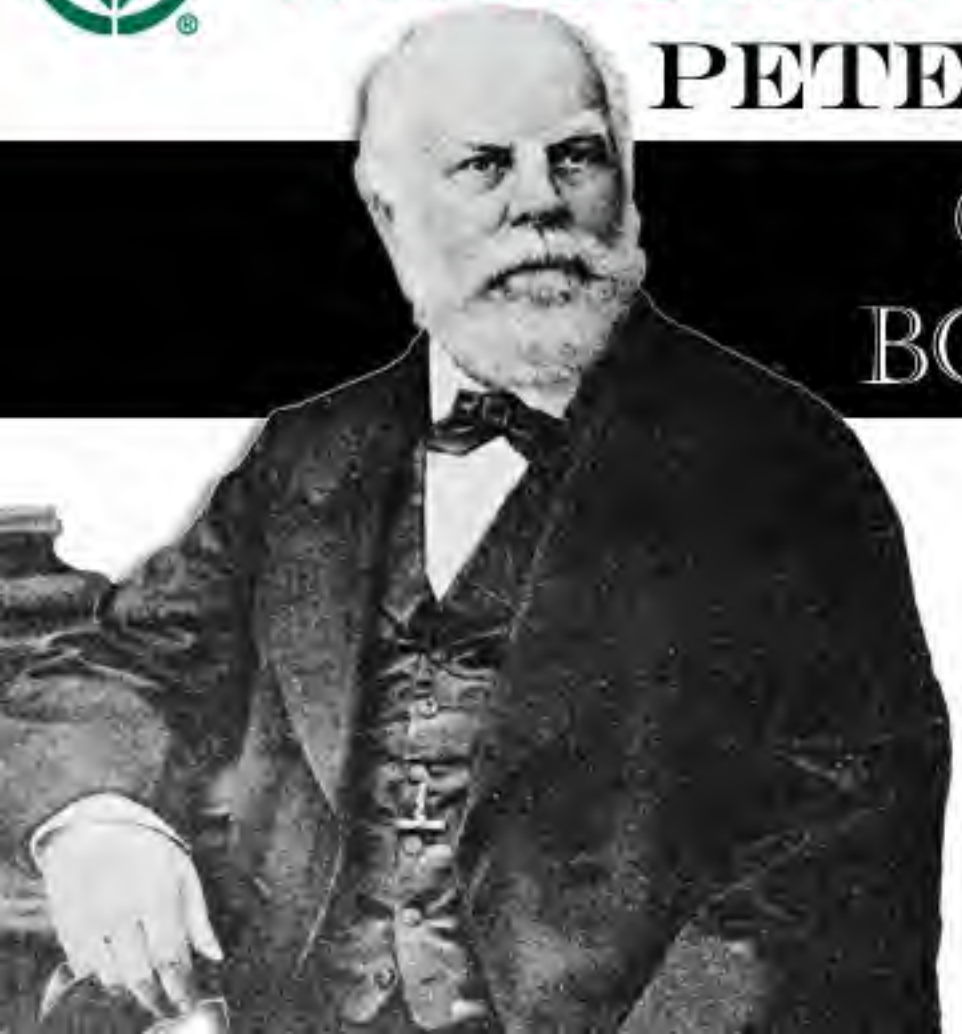

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THE OAKS

OF THE UNITED STATES.

By DR. GEORGE ENGELMANN.

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THE OAKS OF THE UNITED STATES.

By Dr. George Engelmann.

We have quite a large number of oaks in the United States, which for more than a hundred years have attracted the attention of botanists, and we thought we knew them pretty well, i.e. we thought we could distinguish, limit, and group the species. That may have been so, to a great extent, in the old States; but when the Rocky Mountains came to be explored, and the regions west of them, new forms were discovered, and often on single specimens, and not rarely on imperfect ones, species were founded and incompletely described, so that now a straight, clear path through such intricacies is difficult to find.

A striking example of the deceptive polymorphism of these western oaks is furnished by the common Rocky Mountain scrub-oak. This interesting species grows on the foot-hills of the eastern slope of the mountains of Colorado, sparingly near Denver, scarcely north of that city, but abundantly southward, about the Pike's Peak region, and thence extends through New Mexico eastward into Texas and westward through Utah and Arizona into Southern California. The centre of distribution perhaps, at all events the classical locality of this species, are the mountains above Cañon City in Southern Colorado.

In the valley and on the mountain slopes about this place the oak thickets abound, 6–8 ft. high, single trees occasionally 4 or 6 inches thick and rising up to 12 or 15 feet, rarely higher. The leaves are 3–4 inches long, broadly obovate, deeply lobed, sometimes pinnatifid, underneath stellate-pubescent; the broad lobes obtuse

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or retuse, often again 2–3–lobed. They bear middle sized or small oval acorns in more or less knobby hemispherical cups. Scattered copses of these broad-leaved oaks, often of a beautiful brownish-purple in September, accompany us to within a few hundred yards of the top of the cañon, but here the character of these shrubs changes: the bushes are lower, the leaves smaller and in outline narrower, the lobes narrower and mostly undivided, but still obtuse. Now we near the precipice itself; from the ragged, dizzy edge we here and there get a glimpse of the young Arkansas, whose clear green waters toss and foam, twelve or fifteen hundred feet under us, through the inaccessible gorge, rushing towards the plains. The oak bushes accompany us even here, but now they are only 4–6 feet high, with leaves 2 inches long, ovate-lanceolate in outline, no longer lobed, but coarsely dentate, the acute teeth terminating in a sharp point; the acorns are scarcely different from those noticed before. A few steps more and we have reached the brink of the precipice itself: oak bushes here too, but only 3 or 4 feet high, with small (1 inch long), oval, firm, almost cartilaginous, semipersistent, spiny-toothed leaves, here and there with only very few teeth or quite entire; the acorns proportionately smaller, of the same short oval shape, or often elongated from an unusually small, scarcely knobby, and sometimes peduncled cup.

We feel satisfied that we might have abundant material to characterize several distinct species, certainly 4 or 5 well marked forms, and, indeed, they have been considered such. The first is Nuttall's *Quercus Gambelii* (*Q. stellata*, var. *Utahensis*, D. C. Prod.); the second is *Q. alba*, var. *Gunnisoni* of Torrey; the third, with acutish lobes or coarse teeth, is Torrey's old *Q. undulata* of Long's Expedition, the first oak obtained from these mountains, and described about fifty years ago; the fourth, from the edge of the precipice itself, is what has often been mistaken for Torrey's *Q. Emoryi*, or what has been named *Q. pungens*, Liebm., in part; with it occur entire-leaved forms which seem to unite with this as a fifth form the *Q. oblongifolia*, of the same author, and *Q. grisea*, Liebm. As a large and broad-leaved southeastern form somewhat allied to *Q. Gambelii* I consider *Q. Drummondii*, Liebm. In herbarium specimens they all appear distinct enough, but, looking around us, the very abun-

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dance of material must shake our confidence in our discrimination: within the compass of a few hundred yards we find not only the forms above distinguished, but numbers of others which are neither the one nor the other, but which are intermediate between them and clearly unite them all as forms of one single extremely polymorphous species.

If one oak behaves thus, why not others? Thrown into a sea of doubt, what can guide us to a correct knowledge?

Though oaks are so common and such well-studied plants, I venture in the following pages to repeat old observations in order to combine with them some which I think are new, and which will help to throw a little more light on the subject.

The TRUNK—its BARK as well as its WOOD—is what we first contemplate, and this at once takes us to one of the principal points I wish to discuss.

That the *trunk* is that of a large, sometimes one of the largest, or of a middle-sized tree, or occasionally that of a shrub, even a very low one, is well known. On the Atlantic slope of the continent most species of oaks make trees and only a few are known as shrubs; I can now recall not more than one species, the live-oak of the south, which occurs in both forms: usually an immense tree, it occasionally bears a rich harvest of fruit as one of the smallest bushes. But it is different on the Pacific slope; there we find many oaks as trees in the lower countries, and as shrubs, usually with smaller foliage and smaller fruit, in the mountains. The lesser number of oaks seem to occur solely in one or in the other of these forms.

Examining the *bark*, we at once become aware of the fact that the popular distinction of "White-oaks" and "Black-oaks" is based on correct observation. The paler, ashy-gray bark of the former and the darker, often nearly black, color of the latter corresponds, as will be shown, with other essential characters, and well marks the two principal groups of our American Oaks. The bark of the White-oaks is inclined to be scaly or flaky, that of the Black-oaks is usually rougher and deeply cracked and furrowed.

The *wood* of the White-oaks is tougher, heavier, and more compact—the only oak-wood which is fit to be used by the wheelwright or cooper, and is for their purposes unsurpassed. The wood of

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the Black-oaks is brittle and porous, makes poorer firewood, and, made into barrels, holds only dry substances. Undoubtedly the microscopical investigation of both classes of oak-wood will scientifically establish and confirm these distinctions.

While many other trees, such as Pines, Walnuts, Hickories, Gleditschia, etc., grow rapidly in the first decades of their life, and make narrower and narrower annual rings as they grow older, the oaks either hold their own, the annual rings being as wide in age as they are in youth, or they grow more rapidly after the first 50 or 100, or even 150 years of their existence.

The *winter-buds*, especially the terminal ones, show some characteristic differences; they are larger or smaller, acute or obtuse, smoothish or hairy or tomentose; *Quercus Garryana* can be readily distinguished from all the allied Californian oaks by its large, pointed, tomentose winter-buds.

In the LEAVES, so extremely variable in form, certain types are generally recognized. It is not here the place to expatiate on these well-known topics; but I may be allowed the observation, that those oaks, which in the perfect state have deeply-lobed or pinnatifid leaves, show in young shoots or on adventitious branchlets less divided or only dentate, sinuate, or even entire leaves (e.g. *Q. alba*, *stellata*, *falcata*, *coccinea*, *palustris*, etc.), while, singularly enough, the oaks whose leaves in the adult tree are entire or nearly so, often have on the young shoots dentate or lobed leaves. I need for examples only refer to *Q. aquatica*, *Q. Phellos*, and *Q. virens;* and even *Q. nigra* belongs here.

The *vernation* of the oak leaves has sometimes been mentioned as conduplicate, meaning that the upper sides of both halves of the nascent leaf are applied together, and this really is the case with most oaks which I have been able to examine in this early stage. We find it both in White and Black-oaks—almost always, I believe, in those with broad and deeply-lobed leaves; I mention only *Q. alba*, *macrocarpa* and *Garryana*, *Q. coccinea* and *palustris*, and also the forms allied to *Q. Prinus*, even those with narrower, dentate leaves. In the more deeply-lobed, broad-leaved Black-oaks the two halves of the leaf are, besides, plicate parallel with the principal nerves.

Next to these range the oaks with the young leaves concave and imbricately covering one another. Such we find in *Q. stel-*

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lata of the first, and *Q. nigra* of the second group, both with densely tomentose, thick, young leaves. In other oaks, mostly such as have broader and more or less entire leaves, the young leaves imbricatively cover one another like those last mentioned, but are convex on the upper side, with the edges turned down or back. Such is the case in *Q. cinerea*, *myrtifolia*, *agrifolia*, *aquatica*, *chrysolepis*, and, I believe, also in *Q. undulata*, and in *Q. Wislizeni;* I find the same to be the case in the deeply lobed *Q. falcata*.

The narrow-leaved oaks of both sections have revolute young leaves, the halves being spirally rolled backwards towards the midrib, so that only the upper side of the leaf is exposed; the point of the young leaf is somewhat spreading so that the branchlet has a squarrose appearance, while in those with imbricative vernation it is compact. I find the revolute leaf in *Q. virens*, *pumila*, *Phellos*, *heterophylla*, and *imbricaria*. In *Q. Catesbæi* I observe an inflexed vernation, the long bristle-pointed lobes of the nascent leaf being curved down over the still younger one.

I believe that the characters of vernation will not only help to distinguish allied species or doubtful varieties, but will also assist in unravelling the intricate questions of hybridity.

The young leaves of almost every oak are coated with a dense stellate down, which in some (*Q. alba*, *rubra*, etc.) is early deciduous, or it disappears later, or is entirely persistent. Besides these stellate one-celled hairs, several species, those with a clammy feeling of the young leaf, have another kind of hair, single or a few stellately connected, consisting of several cells, obtuse or clavate, sometimes branched, and often colored, apparently glandular. I notice these articulate hairs, among the White-oaks, in *Q. stellata*, and less conspicuously in *Q. macrocarpa;* among the Black-oaks, in *Q. nigra*, *myrtifolia*, *cinerea*, *falcata*, *aquatica*, and *laurifolia;* in *Q. chrysolepis* the characteristic "golden scales" are no scales, but consist entirely of such articulated yellow hair, and the young *Q. Catesbæi* has the same rusty coating.

The *venation* and more or less distinct *reticulation* of the leaves also present characters not to be neglected; by them, e.g. two easily confounded Californian oaks, *Q. agrifolia* and *Wislizeni* can readily be distinguished even in sterile branchlets.

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The persistence of the leaves is a good character in some species, while in others it is unreliable; *Q. pumila* and *laurifolia* on the eastern and *Q. agrifolia* on the western coast sometimes retain their leaves until the new ones are fully developed, and other specimens, even in the same neighborhood, lose them before the buds swell; some have deciduous leaves northward and partly persistent ones southward. The broad-leaved forms of *Q. undulata* are decidedly deciduous, while those with small, coriaceous, spiny-toothed leaves retain them through part of the winter, or, towards their southwestern limit, even into summer. Only such oaks ought to be called evergreen which retain the greater part of their old leaves at least until the new ones are fully grown; the leaves of some oaks persist even into the third year.

The MALE FLOWERS are important for the diagnosis of some species, and to some extent even for the grouping of them. I pass by the form and pubescence of the bracts and of the calyx lobes as well as the pubescence of the anthers (among all our oaks only observed in *Q. stellata* and *virens*); even the sometimes present cusp or point of the anthers seems to be of lesser value, because variable in some species. Of greater importance is the size and the number of the anthers. The smaller and more numerous (usually from 5 to 8 or even 10, rarely only 4) occur in the White-oaks, while in the Black-oaks the anthers are usually larger and fewer, as a rule only 4, in some species as many as 5 or 6; only in *Q. agrifolia*, which also shows other abnormal characters, 6–8 stamens are the rule, and sometimes 10 are found. The pollen-grains of both groups have a diameter of about 0.03–0.04 mm.

In numerous flowers of a certain tree of *Q. nigra* I have seen abortive pistils with prominent filiform styles—singularly enough always 2, where we might have expected 3. In flowers of *Q. agrifolia* the connective of the anthers was seen to elongate, the cells to dwindle down and finally to disappear.

The FEMALE FLOWERS furnish valuable characters to distinguish the principal groups of our oaks. The pistil consists normally of 3 carpels and 3 stigmas; not rarely 4 occur, and in some Californian species (*Q. agrifolia* and *Wislizeni*) I have repeatedly seen as many as 5. The stigmas in our species are dilated, retuse, or emarginate; in the White-oak group they are

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sessile, or rarely (and that sometimes in the same species) borne on short, more or less erect, styles; in the Black-oaks we always find them on longer, patulous, or recurved styles.* As the stigmas are measurably persistent, we often recognize this difference even in the mature fruit.

The FRUIT exhibits the most important characters in the period of its maturation, first noticed by Michaux, and especially in the position of the abortive ovules, the beautiful discovery of A. De Candolle. But before I speak of these I must allude to the position of the fruit on the branch. It is single or clustered in the axils of the leaves or their scars, sessile, or more or less peduncled. In the Black-oaks the peduncle is short or missing, but in the White-oaks it is sometimes several inches in length; its presence, however, is of very little specific value, as in many species either sessile or peduncled acorns are found. In some oaks this feature is connected with slight differences in the length of the petiole, or the shape of the leaf; the distinction between the European *Q. Robur* and *Q. pedunculata* is based on such differences, and we have an analogous difference in our *Q. alba*, where, at least here in the Mississippi Valley, the form with deeply pinnatifid leaves has usually peduncles as long or little shorter than the acorn, and the other form with more broadly-lobed leaves has shorter peduncles or sessile fruit; but sometimes we find sessile and peduncled fruit on the same tree. Some White-oaks have always sessile or nearly sessile acorns, as *Q. stellata*, while *Q. bicolor* always bears them on long peduncles.

The acorns mature either in one season or in two, and generally speaking we find the annual maturation among the White-oaks and the biennial maturation in the Black-oaks, but the exceptions to this rule prove that this peculiarity is not necessarily connected with the essential characters of the two groups. We have one western White-oak, *Q. chrysolepis*, with biennial fruit, and three Black-oaks with annual maturation, *Q. pumila* of the east, and *Q. agrifolia* and *Q. hypoleuca* of the west.

The biennial maturation is easily recognized in the oaks with deciduous leaves; the tree is never without younger or older fruit,

* A group of White-oaks with biennial fructification, peculiar to Southern Europe and Eastern Asia, the best known representatives of which are *Q. Cerris*, *Q. Pseudo-Suber*, and *Q. occidentalis*, differs from all these by their patulous or recurved styles bearing ligulate, acutish stigmas.

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or, from May to September, with both; the older acorns are then seen on the older, leafless part of the branchlet, and the young, incipient ones on the younger, leafy part. In oaks with persistent leaves some difficulty may arise from the peculiarity that the branchlets which had flowered the previous year, and are now maturing the fruit, often in the second year do not elongate or make new leaves or new wood—in short, do not perform any function but the maturation of the fruit. In this case the fruit is found near the end of the branchlet, absolutely as if it were an annual fruit; but the appearance of the leaves as well as of the epidermis of the branch proves them to be over a year old, and wherever a new shoot of the present year can be discovered, the difference between this and those of the last year easily solves any doubts. In *Q. chrysolepis* this peculiarity is quite striking; very rarely (at least in the herbarium specimens examined by me) the fruit-bearing branchlets elongate and again bear flowers, which is the rule in our deciduous biennial oaks.

The cup of the acorn, an involucral organ, is in all our species covered with imbricated scales, appendicular organs which simulate bud-scales, and even occasionally seem to assume a pseudo-phyllotactic arrangement. In the Black-oaks these scales are membranaceous and never thickened at base; in the White-oaks, on the contrary, they sometimes have herbaceous tips and, at least the outer and lower ones, are always more or less thickened, inflated, or knobby at base; they are very thick, e.g. in *Q. alba* and *lobata*, and very slightly thickened in *Q. stellata* and *Garryana;* in *Q. macrocarpa* they are herbaceously tipped.

The shell of the nut or acorn is thinner in the White-oaks and thicker in the Black-oaks; a much more important and striking character is, that in the former its inside is dark, smooth, and even shining, or rarely pubescent, and in the latter densely silky-tomentose, a difference which, I believe, is constant.

Only one of the 6 ovules of the oak-ovary is developed, while the 5 others persist as small but distinctly recognizable oval, dark colored, pendulous bodies, outside of the seed-coat, in the White-oaks at the base of the perfect seed, in the Black-oaks just below its tip. Only in one of our species, *Q. chrysolepis*, are they intermediate or lateral, in some acorns almost basal, and in others scattered over the side from near the base to two-

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thirds up. DeCandolle has observed the same in the Cork-oak of Europe and in some Mexican White-oaks. The Black-oaks with annual fructification have these ovules always suspended near the tip of the seed, and are in this respect undistinguishable from the regularly biennial Black-oaks.

It is well known that in the southeastern Live-oak both cotyledons are united into one mass—a singular but isolated fact which has no systematic significance.

In the foregoing pages I have purposely left aside the very peculiar Californian *Q. densiflora*, which is in every respect different from the other oaks, and thus far the sole representative of a peculiar group named by DeCandolle *Androgyne*. In many respects it is more a chestnut than an oak, for it has, just like the chestnuts, the same dense-flowered, erect male spikes, 10 stamens to each flower, very small anthers on long filiform filaments, with very small pollen-grains (0.017 mm. in diam., not much more than half as large as in other oaks), and in the female flowers slender, terete, pointed stigmas, grooved above. In place of the spiny involucre of the chestnut our plant has a spiny cup, and is thus made an oak and not a chestnut. The maturation is biennial. The shell of the nut is thicker and harder than in any other of our oaks, the inside thickly tomentose, and the abortive ovules are found near the top of the seed. The wood is brittle and worthless.

It results from these investigations that our oaks, leaving again aside the one last mentioned, arrange themselves into two great groups, often alluded to above as the White-oaks and the Black-oaks.

The *White-oaks* are characterized by paler, often scaly, bark, tougher and denser wood, and sessile or subsessile stigmas, and bear the abortive ovules at the base or rarely on the side of the perfect seed. Besides this, the leaves and their lobes or teeth are obtuse, never bristle-pointed, though sometimes spinous-tipped; their stamens are more numerous, the scales of the cup more or less knobby at base, the inner surface of the nut glabrous or (rarely) pubescent; the fruit generally matures in the first year.

The *Black-oaks* have dark, furrowed bark, brittle and porous

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wood, styles long and spreading or recurved, abortive ovules always near the tip of the perfect seed. The leaves and their lobes are bristle-pointed, at least in youth; lobes and teeth acute; teeth sometimes spinous. Their stamens are usually less numerous, the scales of their cup membranaceous, the inner surface of their nut always tomentose; the fruit generally matures in the second year:

We may then arrange our oaks in the following order:

QUERCUS, Lin.

I. **Lepidobalanus,** Endl.: Amenta mascula pendula; pollinis cellulæ 0.03–0.04 mm. latæ; flores feminei a masculis distantes: stigmata dilatata.

A. LEUCOBALANUS: Ovula abortiva infera vel raro lateralia; stamina plerumque 6–8; stigmata sessilia vel subsessilia; nux intus glabra s. rarissime pubescens.

* Maturatio annua; nux intus glabra; ovula abortiva infera.

† Folia decidua.

Q. lyrata,[1] *macrocarpa,*[2] *alba, lobata, stellata, Garryana, bicolor, Michauxii,*[3] *Prinus,*[4] *prinoides, Douglasii, undulata.*[5]

†† Folia sempervirentia.

Q. dumosa,[6] *Emoryi,*[7] *reticulata,*[8] *virens.*[9]

** Maturatio biennis; nux intus pubescens; ovula abortiva infera vel lateralia; folia sempervirentia.

Q. chrysolepis.[10]

B. MELANOBALANUS: Ovula abortiva supera; stamina plerumque 4–6; styli elongati demum recurvi; nux intus sericeo-tomentosa.

* Maturatio annua; folia persistentia s. subpersistentia.

Q. agrifolia,[11] *hypoleuca,*[12] *pumila.*[13]

** Maturatio biennis.

† Folia decidua.

Q. palustris, rubra, Sonomensis, coccinea,[14] *ilicifolia, Georgiana, Catesbœi, falcata, nigra, cinerea,*[15] *aquatica, laurifolia,*[16] *heterophylla,*[17] *imbricaria, Phellos.*

†† Folia sempervirentia.

Q. Wislizeni,[18] *myrtifolia.*[19]

II. **Androgyne,** A. DeC.: Amenta mascula erecta, basi flores femineos gerentia; pollinis cellulæ fere 0.017 latæ; stigmata linearia.

Q. densiflora.

NOTES.

1. *Quercus lyrata,* Walt., extends as far north as *Taxodium* does, to the banks of the lower Ohio in Illinois.

2. *Q. macrocarpa,* Michx., is extremely variable in the size of its acorns, and especially in the depth and the margin of its cup, which sometimes

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covers the acorn scarely one-half, usually three-fourths, and occasionally entirely; the margin is profusely or sparsely fringed. —Throughout the north-west, north of the Missouri river, a low scrubby form is found, which might be designated as var. *depressa*, as it is undoubtedly the *obtusiloba* β. *depressa*, Nutt. gen. 2, 215, which has smaller leaves and much smaller acorns than the species, but is clearly a form of *macrocarpa*.

3. Q. *Michauxii*, Nutt. gen. 2, 215, excl. syn.—The figure of Michaux, quoted by Nuttall, refers to Q. *bicolor*, and none of his figures represent our plant. Elliott adopts Nuttall's name, but Chapman as well as DeCandolle consider it a form of *Prinus*. Q. *Prinus* was described by Linnæus with *foliis obovatis utrinque acuminatis*, which sufficiently well agrees with all the forms of *Prinus* proper. Our plant is distinguished by having the leaves obtuse, or mostly cordate, at base; thicker, more leathery, and tomentose, on the lower side; and the male flowers 10-androus. All the forms of *Prinus* proper have a very deciduous pubescence on the lower side of the leaf, which is acute or acutish at base.

4. Q. *Prinus*, Lin., would then comprise Michaux's varieties, *palustris*, *monticola*, and *acuminata*.

5. Q. *undulata*, Torr., has been treated of in the introduction to this paper; the different forms, there also enumerated, are—α. *Gambelii* (Q. *Gambelii*, Nutt. and probably Q. *Drummondii*, Liebm.); β. *Gunnisoni* (Q. *alba*, var. *Gunnisoni*, Torrey); γ. *Jamesii*, Torrey's original plant, figured in Ann Lyc. N.Y. 2, t. 4; the original figure reproduced with slight alterations in Nuttall's N. Am. Sylv. 1, t. 3; δ. *Wrightii*, often confounded with Q. *Emoryi*, and apparently one of the forms comprised by Liebmann in his Q. *pungens*. Q. *oblongifolia*, Torr., and Q. *grisea*, Liebm., seem to be forms with more or less entire leaves; or the latter may perhaps have to be referred to the Mexican Q. *microphylla*.

6. Q. *dumosa*, Nutt., N. Am. Sylva, 1. p. 7; Torrey, Bot. Mex. Bound. p. 207. Q. *acutidens*, Torr. ib. tab. 51, is a larger form of the same. Q. *berberidifolia*, Liebm., DeProd. 16, 2, p. 36, seem to belong here either entirely or at least in part. A shrub of the southern part of California, often very squarrose, sometimes with slender and erect branches; leaves oval, obtuse, often cordate or obtuse at base, spinous-dentate or sometimes entire, dark green above, hoary tomentose or pubescent below, from ¼ to ¾ or sometimes 1 inch long; fruit sessile; cup strongly tuberculate, black, between 2 and 6 lines in diameter; acorn large for the size of the plant, oval, or small and narrow.

7. Q. *Emoryi*, Torr. Emory Rep. 1848, p. 151, t. 9, Q. *hastata*, Liebm. Quite distinct from Q. *undulata* var. *Wrightii*, which is often confounded with it; the peduncled acorn of Torrey's figure ~~may~~ belong to that form of *undulata*. This pretty Arizonian species was collected by Emory in 1846, and soon afterwards by Wright, and then not again until Dr. Rothrock, a year or two ago, brought back fine specimens from Lieut. Wh~~ipple~~'s Expedition. The leaves are not roundish or oval and pale as in *Wrightii*, but lanceolate, cordate at base, and dark green; the acorns in all the

herbarium and Texan and seeler

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specimens seen by me are sessile, the bright brown scales of the cup ~~only~~ ~~slightl~~y thickened at base./ styles long, not to mentone ins. &c

8. *Q. reticulata*, H. B. K., has been found in Southern Arizona by Dr. Rothrock, in the expedition just mentioned.

9. *Q. virens*, Ait. A shrubby form is var. *maritima*, Chapm , *Q. maritima*, Willd., from which var. *dentata*, Chapm., cannot be separated; both have shorter and often larger acorns on shorter peduncles than the species; the former is the larger shrub, rarely as much as 10 feet high, with usually entire lanceolate leaves; the latter often bears fruit when only 1–1½ feet high; leaves sometimes dentate or sinuate-dentate, 1–2 inches long; vigorous ground shoots occasionally produce broad oval, entire, or dentate leaves, 3–4 inches long and 1½–2½ wide.

10. *Q. chrysolepis*, Liebm., has so often been spoken of in the foregoing pages that little need be added. Its fructification was misunderstood until the abundant material, brought together by Prof. W. H. Brewer for the California State Survey, permitted me to clear it up. The size of the plant, of the leaves, and of the fruit, is extremely variable; and even the yellow pubescence, which has given it its name, is neither persistent, nor is it present in all cases. Young vigorous shoots or young trees have spiny-dentate leaves; older trees, especially on fertile branches, usually entire ones. The acorns are sometimes very large and the shallow cup extremely thick: this is the form Torrey (Pacif. R.R. Rep. v. 365, tab. 9) has described as *Q. crassipocula;* Dr. Parry sends from San Bernardino still larger cups, 1¾ inches in the outer diameter. Dr. Kellogg's *Q. fulvescens*, in Proc. Calif. Ac. 1, 67 & 71, seems (from specimens seen in Hb. Brewer) to refer to the form with middle-sized acorns and cups of the ordinary shape, without that unusual thickening; his *Q. vaccinifolia*, ib. 1, 96 (106 ed. 2) is a small-leaved mountain form. Of this variety specimens are found entirely destitute of the yellow, scurfy pubescence even in the earliest youth. The anthers of this species, usually 10 in number, are always strongly pointed; the broad stigmas are closely sessile. The lateral position of the ovules has been mentioned.

11. *Q. agrifolia*, Née, the first western oak that became known (1802), is quoted by the author as inhabiting "Nootka Sound" and California perhaps by mistake, as now it does not seem to be known much north of the Bay of San Francisco, and it extends as far south as the southern boundary of the State, but does not ascend the mountains. It is a fine large almost evergreen tree, but makes miserable timber and even poor firewood. The old leaves partially fall off in winter, so that the heads begin to look less dense towards spring; in some trees the last leaves have fallen before the young ones are developed, but generally they do not come off entirely before the young verdure covers the branches. Dr. Bolander remarks that occasionally odd-looking trees are observed which in spring retain all their old leaves without bringing forth flowers or young shoots—a state of things which resembles the condition of *Q. chrysolepis*, above alluded to; that species, however, performs the function of maturing its

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fruit, though it bear no young leaves, while in this case there would be in spring an almost absolute winter-like stagnation of the vegetation. It has certainly an annual fructification, but is in every respect, except in the number of the large stamens (6–8 and often more), a regular Black-oak. The acorn is always long pointed, whence the name Torrey gave it, *Q. oxyadenia*, (Sitgr. Rep. tab. 17), is not inappropriate.

A southern variety of this species is shrubby, with smaller leaves, occasionally pubescent, and with smaller but very abundant fruit. From the often very similar *Q. Wislizeni* it can, even without fruit, always be distinguished by the dull, pale upper surface of the leaves, which is usually convex, and by the absence of reticulation on it.

12. *Q. hypoleuca* I name an Arizona oak which Torrey, in Mex. Bound. Rep. p. 207, refers to *Q. confertifolia*, H. B. K., a species with biennial fructification and slightly pubescent leaves. Our plant is characterized, besides its annual acorns, by lanceolate thick leaves with revolute margins and a white tomentose lower surface. The 5-lobed calyx is scarcely hairy and bears 4 stamens; no bracts seen even before the flowers open.

13. *Q. pumila*, Walt. Fl. Carol. p. 234. Michx. Sylv. tab. 17 (where the fruit is erroneously represented as biennial, otherwise the figure is good). This interesting shrub, though first described nearly a century ago, has only, through the efforts of Dr. J. H. Mellichamp, become properly known in the last few years. Living in the immediate vicinity of its habitat, the pine barrens of the low country of South Carolina, this acute observer has aided me in the most liberal manner in studying this as well as other difficult oaks of that region.

Q. pumila is called the *Running-oak* because by the aid of its widespreading stolons it covers large patches, sometimes acres, with its thickets. It is often, especially where kept down by the frequent fires, only 1–2 feet high, and has been seen loaded with flowers when only of 6 inches; in other localities it grows 8–10 feet high, with stems 1 inch in diameter. The leaves, revolute in vernation, are usually about 2 inches long, lanceolate, entire and often undulate, only occasionally dentate-lobed, but in vigorous shoots sometimes broad ovate and deeply and acutely lobed; another form has obovate obtuse leaves. They are slightly pubescent when young, but soon become quite glabrous, persist through the winter and occasionally beyond the flowering period. In the male flowers I find pretty regularly 4 stamens, and in the female 3 long recurved styles. The globose fruit in its shallow cup is nearly sessile in the axils of the same year's leaves.—*Q. pumila*, Walt., Michx. Sylv., Nutt. gen., Elliott Flor.; *Q. Phellos* var. *pumila*, Mich. Querc. & Flor.; *Q. cinerea* var. *pumila*, Chapm., A. DeCand. Prod.

Var. *sericea* has similar narrow, or larger, ovate-lanceolate leaves, always silky-white underneath; the larger leaves on fertile branches grow over 4 inches long by $1\frac{1}{4}$ inches in width, and on sterile shoots even larger. —*Q. sericea*, Willd., Pursh.; *Q. Phellos* var. *sericea*, Ait.

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The leaves of the glabrous form resemble those of *Phellos* and of the silky variety those of *cinerea*, and without the fruit they could not well be distinguished from some forms of them.

14. *Q. coccinea*, Wang. I have, with some hesitation, followed DeCandolle and Gray in uniting with this species *Q. tinctoria*, Bart., which has broader, less lobed and firmer leaves, and a deep yellow colored inner bark; but I suspect that specific differences may yet be discovered.

15. *Q. cinerea*, Michx. In specimens from S. Carolina I find, together with the ordinary stellate pubescence, an abundance of yellow articulated hair on the young leaves, while in flowering Texan specimens it seems to be entirely wanting.

16. *Q. laurifolia*, Michx., appears after all to be distinct from *Q. aquatica;* whether entire or lobed, the leaves of the latter have a cuneate outline widest in the upper third or at least above the middle; the calyx lobes are larger and very conspicuous, and the filaments enclosed and only the anthers exsert. *Q. laurifolia* has lanceolate oblong leaves, widest about the middle whether entire or lobed; the calyx lobes are much smaller; the filaments ~~[etc.]~~ exsert; this in flowering specimens of both species from Bluffton, the only ones which I could compare. A specimen from the gulf coast of Mississippi has oval entire coriaceous leaves 4 inches long and 1½ inches wide, while those of my South Carolina plants are narrower, and rather approach to *Phellos*, but never to *aquatica*. They usually persist until the budding time, but not beyond it; therefore I would not call them really evergreen.

17. *Q. heterophylla*, Michx., must, I believe, like the foregoing, be readopted as a distinct species, as it is neither a variety of *aquatica* or *Phellos*, nor a hybrid of any of these oaks. As I have not yet seen flower or fruit, my opinion, which stands alone in opposition to the best recent botanists, must for the present be taken for what it may be worth.

I distinguish Michaux's species by its long and distinctly petioled leaves, which in vernation are revolute, and are glabrous from their earliest age. My specimens, natives from New Jersey, cultivated ones from Bartram's and Marshall's gardens, and from the European gardens at Verrière. Herrnhausen and Prague, the latter fertile, agree in this respect among themselves and with Michaux's figure in his Sylva. In all these specimens the leaves are lanceolate, entire, or sinuate-dentate, 3 or mostly 4–6 inches long, 1–2 inches wide, on a petiole 3–9 lines long. In the allied species, *Phellos*, *laurifolia*, and *aquatica*, the petioles are usually inconspicuous or merely 1–2 lines long; only *Q. imbricaria*, which is also readily distinguished by its pubescence, has plainly petioled leaves. I suspect that some specimens claimed for *Phellos* are entire leaved forms of the species in question. May these suggestions induce the local botanists of the lower Delaware region, the favorite home of this oak, to work up the species.

18. *Q. Wislizeni*, A. DC. With his usual acumen, A. DeCandolle discovered this species in a small fruiting specimen, brought by Dr. Wislize-

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nus in 1851 from the American Fork of the Sacramento River, but, through a mistake of mine, he located it near Chihuahua. Since then nothing further, I believe, has been published about this remarkable oak, though an abundance of material and very full notes have been gathered by different collectors, principally by Prof. W. H. Brewer and Dr. H. Bolander.

This species is found throughout the western parts of California from Shasta to San Diego, principally in the region of the foot-hills, but does not ascend the higher mountains. In some localities it makes a "magnificent tree" 40 to 60 feet high, with a trunk occasionally 6 feet in diameter, but branching 5 or 6 feet from the ground, as most of the large Californian oaks of both groups are wont to do. On the coast ranges from Monte Diablo to San Diego it also occurs as a small shrub with small leaves.

The bark is pale and smoothish in younger, very rough and black in older trees. The firm, leathery leaves persist 14 or 15 months on the branches; they vary excessively, often on the same tree, from broad ovate to narrowly lanceolate; cordate, obtuse, or acute, at base; the margin entire, or with a few teeth or sharply and closely dentate; shoots or young trees have usually dentate, old and fertile ones more commonly entire leaves. In the earliest age the leaves are very slightly concave, and in vernation imbricate; they bear on both sides articulated hair, but soon become glabrous; the full grown leaves are mostly dark green and shining, and delicately reticulate, principally on the upper surface. They are usually 2–4 inches long and half as wide, or rarely narrower; petioles 5–9 lines long; in var. *fruticosa* the leaves are only 1–1½ inches long, oval, entire, or often very sharply and deeply lobed-dentate; petioles 1–2 lines long.

The rhachis of the aments is stellate-canescent, or nearly glabrous; calyx-lobes 5 or 6, large and broad, nearly glabrous or ciliate-bearded; anthers 3–6, often pointed. Bracts of the sessile (or often peduncled) female flowers large, orbicular, membranaceous; the long, recurved styles not rarely 4 or 5 in number. Acorns always elongated, 9–18 lines long, immersed ⅓ to ⅔ in the cup, which I find varying from 6–11 lines in depth and 5–6 lines in width; cup-scales elongated acutish, light brown, and nearly glabrous.

On one hand this species approaches to *Q. agrifolia*, and on the other to *Q. Sonomensis*.

Dr. Kellogg, in Proc. Cal. Ac. 2, 36 (DC. Prod. 16, 2, 79), scantily describes an oak under the name of. *Q. Morehus*, which I have no means of identifying; possibly it may belong here.

19. *Q. myrtifolia*, Willd. Willdenow's description of the foliage, which cannot possibly refer to any other oak, together with his locality, makes it certain that in Dr. Mellichamp's very complete specimens we have his plant before us, and, thanks to him, I can now reëstablish this little known and often doubted species. It grows on the poorest sand ridges near Bluffton, together with *Pinus australis*, very rare there, but apparently extending along the coast to Florida. It makes an ever-

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green shrub from 1½–2, usually 4–5, and up to 8 feet high. Leaves rounded ovate, cordate, obtuse, or sometimes acute at base, obtuse and in youth bristle-pointed at tip, revolute on the margin, thick and leathery, persisting 15–18 months. Leaves vary sometimes to broadly obovate, or are rarely, in young shoots, sinuate-angled; they are usually 1–1½ or even 2 inches long, but in vigorous ground shoots have been found 2½ and 3 inches in length by 2 in width. The young leaves are densely covered with a rusty, clammy scurf of articulated hair, which after a month or so disappears, leaving a glossy surface. Vernation imbricate; youngest leaves flat with recurved margins. Aments about 1½ inches long with stellate-canescent rhachis, 5 oval pubescent calyx lobes, and a few (mostly only 2–3) small cuspidate anthers. Fruit sessile or usually short peduncled, single or in twos; cup very shallow, about 6 lines wide, with ovate-triangular obtuse scales; gland ovate or subglobose, 5 or 6 lines long, covered by the cup for ⅓ or ¼ of its length.—*Q. myrtifolia*, Willd., Nuttall, Pursh, Elliott, only the first two of which seem to have seen sterile specimens; *Q. Phellos* var. *arenaria*, Chapm.; *Q. aquatica* var. *myrtifolia*, A. DC.

Hybrid Oaks.

The question of hybridity in plants is in every case difficult to solve where its usual character, the sterility of the hybrid, fails us, and where we have nothing to rely on but the rarity and individuality of a form that seems to stand intermediate between two well established species which occur in its neighborhood, and which could be considered its parents.

This is just the case in oaks. All the supposed hybrids are abundantly fertile, and those of their acorns which have been tested have well germinated; in fact, as far as I know, no difference in fertility or germinating power between them and the acknowledged species has been discovered. The seedlings of such questionable individuals do not seem to revert to a supposed parent, a sport of which they might be claimed to be, but propagate the individual peculiarities of the parent; "come true," as the nurserymen express it. At the same time, it is a remarkable fact, that, notwithstanding their fertility, they do not seem to propagate in their native woods; we may properly ascribe this to a lesser degree of vitality in the hybrid progeny, which causes them to be crowded out in the struggle for existence: one of the provisions of nature to keep the species distinct.

White-oaks and Black-oaks are too distinct to hybridize with one another. Thus far no hybrids have been discovered among

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the former, while among the Black-oaks I find six forms, enumerated below, which I consider as real hybrids; of them only a few, usually only single individuals, have become known; their existence cannot well, without straining facts, be considered due to innate variability in a supposed parent. Four of these hybrids have been found in the Mississippi Valley and two in South Carolina. When more carefully looked for, undoubtedly more will be discovered. The four western hybrids all claim *Q. imbricaria* as one of the parents, while the two southeastern ones seem to point to *Q. cinerea;* both are species with entire leaves, and the mixture of such with lobe-leaved forms would of course be more readily discovered from the intermediate leaf-form of the illegitimate offspring; but it remains for further close examination to ascertain whether lobe-leaved species do not hybridize among themselves, or entire leaved-forms also mix together, producing offspring of less strikingly marked characteristics.

That we have to look for one of the parents of all our hybrids to only two species, seems to correspond well with other observations, all pointing to the fact that some species of a genus are more prone to hybridize than others. This is true of *Verbenas*, hybrids of which abound in this neighborhood in numerous forms as well as in a great many individuals; of most of them *V. stricta* appears to be one of the parents, perhaps because one of the most common species, or from some innate quality which makes it mix more readily with others; perhaps from a peculiar structure of the flower which may promote insect agency. Our hybrid Verbenas differ from the hybrid oaks in bearing scarcely any fertile seeds, while at the same time they are so common that evidently they are readily produced anew.

Our oak-hybrids are the following:

Probable Parents.		Name under which described.
Q. coccinea,	*Q. imbricaria*,	*Q. Leana.*
Q. rubra,	"	
Q. palustris,	"	
Q. nigra,	"	*Q. tridentata.*
Q. Catesbæi,	*Q. cinerea*,	*Q. sinuata.*
Q. falcata,	"	

1. *Q. imbricario-coccinea* was first described and figured by Nuttall, about thirty years ago, under the name of *Q. Leana*, Nutt. Sylv. Contin. 1, tab. 5 bis; DC. l. c. 62. The original type was discovered by Mr. T. G.

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Lea, near Cincinnati, and soon afterwards Dr. S. B. Mead found another tree in Hancock Co., Illinois. My specimen, obtained from the first discoverer, has entire or sinuate or dentate or dentate-lobed leaves, 4–6 inches long and half as wide, and even in September slightly pubescent below; lobes acute and bristle-pointed or quite obtuse; base attenuated into a petiole 5–8 lines long; acorns similar to those of *coccinea*, cup shallower with obtuse scales. The leaves in Nuttall's figure have a cordate base. Dr. Mead's tree is similar to Lea's; leaves apparently more commonly entire or undulate-sinuate, 5–7 inches long and half as wide, obtusish at base with a petiole 1 inch long; the pubescence has almost disappeared on the lower side of the autumnal leaf; acorns globose, covered $\frac{1}{3}$–$\frac{1}{2}$ by the canescent cup. Mr. E. L. Greene sends another specimen from Macon Co., Ills.; it is rather more glabrous but otherwise similar, without fruit.—The relationship to *imbricaria* is unquestionable, and it is quite probable that among the lobe-leaved Black-oaks we must look to one of the forms of *coccinea* as the other parent.

2. *Q. imbricario-rubra*. I found this hybrid two years ago in St. Clair Co., Ills., 20 miles from St. Louis, in low, fertile woods where both *rubra* and *imbricaria* form the bulk of the forest. Growth of the tree and bark like *rubra;* leaves ample, 4–8 or 9 inches long, 2–6 inches wide, obtuse or cordate, rarely acute, at base, the smaller more commonly oblong and entire, the larger ones oval or obovate, entire or sinuate, or with a few broad and shallow obtuse or triangular bristle-pointed lobes; in June still downy on the lower surface; petioles $\frac{1}{2}$–1 inch long, pubescent; fruit unknown.

3. *Q. palustri-imbricaria* was observed by me a few years ago, 8 miles west of St. Louis, in a little dell where *imbricaria* abounds; *palustris*, *coccinea*, and *nigra*, together with some White-oaks, were near by; the tree was only 8 inches in diameter but in full bearing. It had, unfortunately, to give way to a railroad track; but ripe fruit was obtained, which to Mr. Meehan of Germantown has furnished fine young plants, completely agreeing in character with the parent.—Leaves, as far as I could see, not revolute in vernation, pubescent on both sides, but completely denudated before the end of May. Full grown leaves broad-lanceolate, mostly acute at base, entire or more frequently with a few (sometimes more) coarse, triangular-lanceolate, acute, bristle-pointed teeth, glabrous on both sides; about 4 inches long, $1\frac{1}{2}$ wide, rarely larger; peduncles 3–4 lines long; cup moderately deep, turbinate at base, 6–7 lines wide, 3-4 high; ovate-obtuse scales, canescent, with bright brown margins.

4. *Q. imbricario-nigra* (*Q. tridentata*, Eng. in Hb.), *Q. nigra* var. *tridentata*, DC. l. c. 64. A single tree, rather small, which was soon afterwards destroyed, was found by me, in the autumn of 1849, on the hills 6 miles east of St. Louis, in company with both supposed parents and *coccinea* and *rubra*, together with some White-oaks. Foliage as well as fruit are of such decided character that the origin of this hybrid can scarcely be doubted; the leaves are rather those of *imbricaria*, with a touch of the peculiar lobation of *nigra*, and the fruit is more like that of *nigra*. Leaves

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elliptical to obovate, entire or often coarsely 3-dentate at the apex, occasionally with a few teeth on the sides; 4–7 inches long, 2 or 3 wide; base rounded or acutish; upper surface dark, shining green, lower one pale, and in September not quite glabrous; petiole 4–10 lines long. Acorns closely sessile; the hemispherical, turbinate, canescent cup about half-enclosing the globose nut.

5. *Q. cinereo-Catesbæi; Q. sinuata*, Walt. Car. 235, DC. l. c. 74. It is quite probable that in the tree observed by Dr. Mellichamp, several years since, near Bluffton, S. C., and not far from Walters' abode, we meet with Walters' obscure and long ignored species. Mr. Ravenel has also observed a similar form in South Carolina, and indicated *cinerea* as one of the parents. Dr. M.'s tree grows on a sandy ridge with *Catesbæi*, *falcata*, and *virens; cinerea* not far off, but rare; it is 40 feet high and well grown, has a "very dark, deeply cracked bark, which is red inside like *Catesbæi*." Leaves 4, rarely 5–6 inches long, about half as wide, attenuated at base into a partially margined petiole, 3–6 lines long; leaf itself oblong to obvate, sometimes almost rhombic; sinuate with shallow obtuse lobes to divaricately dentate-lobed; lobes obtuse, or acute and bristle-pointed, dark green and shining on upper surface, paler but glabrous and with some axillary down beneath. In early youth both sides, the lower more than the upper, are covered with the rusty, articulated pubescence of *Catesbæi*, and are as it seems imbricative in vernation. Male flowers with 4 large, pointed anthers. Acorns sessile; cup hemispherical, turbinate, 8–10 lines wide, 5 or 6 high; nut oval, 8–9 lines high and 6–8 thick, $\frac{1}{3}$ or $\frac{1}{4}$ covered by the cup.—One of the parents is doubtless *Q. Catesbæi*, as the other *cinerea*, *falcata*, or perhaps *aquatica*, present themselves; *falcata* would produce very different leaves, *aquatica* grows in a different soil and would not probably mix with the "barren oak"; so that *cinerea* with its entire leaves remains, though rare there, as the most probable other parent.

6. *Q. falcato-cinerea* is quite a late discovery of the same successful explorer, who found it in the vicinity of the last mentioned hybrid. It still more distinctly shows its parentage.—Leaves oblong, usually obtuse or cordate at base; often entire or with one or a few teeth, or divaricately trilobed, some of them exactly resembling forms of *falcata* var. *triloba;* leaves 3–5, usually 4 inches long, $1\frac{1}{2}$–2 and the lobed ones over 3 inches wide; petiole 6–9 lines long. The upper surface of the leaves is not reticulated as in most allied oaks, but almost entirely smooth, like *Q. cinerea;* pale green; lower side whitish canescent. Young fruit subsessile; no mature acorns seen.

Q. coccineo-ilicifolia, Gray, Man. ed. 5, p. 454, found by Dr. Robbins in Massachusetts, is unknown to me.

Several forms of oaks have at one time or another been considered as hybrids which most probably are varieties or sports of of one or the other of the well-established species, or, in one instance, seem to claim the rank of species themselves.

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Q. olivæformis, Michx., is, according to A. Gray, a variety of *macrocarpa*. After carefully comparing several specimens referred to *olivæformis* with numerous forms of *macrocarpa*, I cannot but fully coincide with this view. Mr. E. Hall of Menard Co., Ills., has a found a tree in his neighborhood which has exactly the leaves of *olivæformis*, as figured by Michaux, lobed so deeply that the midrib is nearly bare, with an ovate fruit larger than that of Michaux (which was most probably incomplete or abortive), and about half immersed in the deep, not fringed, strongly knobbed cup. This specimen has been claimed as a hybrid of *macrocarpa* and *alba* (Amer. Ent. & Bot. 1870, p. 191). Such leaves, however, are not very rare in *macrocarpa*, and I have repeatedly seen in western forms of *macrocarpa* exactly the same kind of acorns, with or without a fringe on the edge of the cup.

Q. runcinata was the name given to a form I found in the richest Mississippi-bottom lands opposite St. Louis, together with *rubra*, *imbricaria*, and *palustris*. From its smaller and narrower, grossly dentate, not lobed leaves, and its smaller fruit, it seemed distinct enough from *rubra*, and was possibly a hybrid of it and some other small-fruited allied oak. But the leaves of *rubra* are so variable in size and outline that most probably DeCandolle (l. c. 60) is right in considering it a variety of *rubra*.

Q. quinqueloba I named a form of *nigra* with 5-lobed leaves, which I found on the hills of St. Louis; DeCandolle (l. c. 64) places it correctly with *nigra*. It is not even a variety, but rather a juvenile state which had become permanent in that tree; young trees or shoots of *nigra* have sinuate-dentate or many-lobed leaves, but in fertile ones the leaves are almost always more or less 3-lobed or 3-dentate. I have since seen a tree which on one fruit-bearing branch had only the leaves of *quinqueloba*, while all the other branches had the regular cuneate 3-dentate *nigra* leaves.

Q. heterophylla, Michx., has by some been considered a hybrid of some species with entire, narrow leaves, and a lobed one; DeCandolle takes it for a form of *aquatica*, and Gray partly for that, partly for a form of *Phellos*. I have above expressed my opinion that it is a good species, not to be confounded with the *lobe*-leaved forms of either.

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